International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Investigation of Microleakage by Conventional and Er: YAG Laser Cavity Preparation

Violeta Dogandziyska, PhD

Department of Conservative Dentistry, Faculty of Dental Medicine, 1 blvd "St. George Sofijski", 1431 Sofia, Bulgaria
Email: *Dogandzhiyska[at]gmail.com*

Abstract: ***Recurrent caries is one of the most common problems after tooth restorative procedures. Despite improvements to resin composite formulations over the years, polymerization shrinkage of the resin matrix is still considered highly relevant in unsuccessful resin composite direct restorations. Therefore, pretreatment of the tooth surface is essential to establish a strong bond between resin and both enamel and dentine. The standard approach for enamel pre - treatment is acid etching. Some researchers have explored the use of lasers to modify the surfaces of teeth intentionally, to improve bonding of restorations. The effect of laser irradiation on surface characteristics is not still completely revealed if it beneficially alters surface specifications or not, and needs more investigations to show if it results in increasing or decreasing the microleakage in comparison to conventional chemical acid etching procedures. The aim of our in vitro study was to investigate the marginal leakage of class V cavities prepared by conventional diamond bur and Er: YAG laser.45 single rooted intact extracted human teeth were used. They were randomly assigned into three groups, dependent on the preparation technique: Group I (n=15) – diamond bur + total - etch technique; Group II (n=15) – Er: YAG laser + total - etch technique; Group III (n=15) – Er: YAG laser + laser etching. Microleakage was assessed according to the depth of dye penetration along the restoration at x 15 magnification. None of the procedures investigated on our study completely eliminated the microleakage. The extent of dye penetration was lowest in the laser - treated and acid - etched group (Group II). The results of our study revealed that the laser irradiation can modify the morphology of the cavity walls and increase the bond strength with the composite filling.***

Keywords: Er: YAG laser, cavity preparation, microleakage, composite

1. Introduction

Recurrent caries is one of the most common problems after tooth restorative procedures. Many authors have attributed recurrent caries, pulp inflammation and necrosis to microleakage. Despite improvements to resin composite formulations over the years, polymerization shrinkage of the resin matrix is still considered highly relevant in unsuccessful resin composite direct restorations. Therefore, pretreatment of the tooth surface is essential to establish a strong bond between resin and both enamel and dentine. Since the report of Buonocuore, the standard approach for enamel pre - treatment has been acid etching. Effective adhesion to enamel has been achieved with relative ease and has repeatedly proven to be a durable and reliable clinical procedure for routine applications in modern adhesive restorative dentistry [13, 15]. The formation of a hybrid layer and resin tags is essential to the establishment of a strong bond at dentine level. One way of achieving this is by a complete dissolution of the smear layer and the demineralization of intertubular and peritubular dentine by means of acid - etching, resulting in an exposed collagen matrix that is infiltrated by resin that polymerizes in situ.

Some researchers have explored the use of lasers to modify the surfaces of teeth intentionally, to improve bonding of restorations [2, 3, 6, 9, 11, 12]. With the introduction of the Er: YAG laser, in contrast to other available lasers, it became possible to remove dentine and enamel more effectively and efficiently. Thermal damage was reduced, especially in conjunction with water spray. Moreover, cavity pre - treatment with Er: YAG laser (laser - etching) was proposed by some authors as an alternative to acid - etching of enamel and dentine: laser irradiation of enamel and dentine has been reported to yield an anfractuous surface (fractured and uneven) and open tubules, both apparently ideal for adhesion [19]. Roughened dentine surfaces with open dentinal tubules without smear layer production were also reported by others. Next to cavity preparation, the ablative effect of Er: YAG laser light in healthy enamel and dentine could also be used for modifying the dental surfaces and eliminating the need for acid - etching [1, 8]. But the effect of laser irradiation on surface characteristics is not still completely revealed if it beneficially alters surface specifications or not, and needs more investigations to show if it results in increasing or decreasing the microleakage in comparison to conventional chemical acid etching procedures.

2. Material and Methods

The aim of our ***in vitro*** study was to investigate the marginal leakage of class V cavities prepared by conventional diamond bur and Er: YAG laser.

45 single rooted intact extracted human teeth were used. They were randomly assigned into three groups, dependent on the preparation technique. All the prepared cavities were class V, positioned on the buccal tooth surfaces above the enamel - cement junction with size: 2x2x2 mm, as follows:

Group I (n=15) – Preparation with a diamond bur (№ 18, A4M 0483 Strauss FG Dia) and air - turbine with water cooling. All samples were treated with 37% phosphoric acid for 15 sec. and rinsed with water for 15 sec.

Group II (n=15) – Preparation with Er: YAG laser λ= 2940 nm (Litetouch, Syneron Medical ltd.).

Irradiation parameters:
Enamel – 700 mJ; 12 Hz; 8, 40 W; non - contact mode; water cooling

Dentin – 400mJ; 20 Hz; power 8 W; non - contact mode; water cooling

All samples were treated with 37% phosphoric acid for 15 sec. and rinsed with water for 15 sec.

Group III (n=15) – Preparation with Er: YAG laser λ=2940 nm (Litetouch, Syneron Medical ltd.).

Irradiation parameters:
Enamel – 700 mJ; 12 Hz; 8, 40 W; non - contact mode; water cooling
Dentin – 400mJ; 20 Hz; power 8 W; non - contact mode; water cooling

All samples were laser - etched for 15 sec. with the same laser and irradiation parameters: 100 mJ; 20 Hz; 2 W.

After application of bonding agent (Adper Single Bond 2), all cavities were restored with composite resin (Valux, 3M ESPE). After polishing the restorations, teeth were stored in distilled water at 37 °C for 24 h, thermocycled from 5–55 ºC for 500 cycles and coated with two layers nail polish 1 mm shorter of the restoration margins in order to prevent the leakage and false positive results. Samples were placed in a 2% methylene blue for 24 h at 37 °C, rinsed with water and longitudinally sectioned. Microleakage was assessed according to the depth of dye penetration along the restoration at x 15 magnification. These were evaluated by two blinded evaluators who assigned a microleakage score (0 to 3), as follows:
0 - no dye penetration
1 - dye penetration along the interface to 1/2 the depth of the cavity wall
2 - dye penetration to the full depth of the cavity wall, but not including the axial wall
3 - penetration to and along the axial wall

Statistical analysis was done with SPSS 19.0 statistical software package, using One - way ANOVA test.

3. Results

The results of dye microleakage in each group are presented in Table 1 (**Table 1**).

Table 1: Microleakage scores obtained for each experimental group (n=15)

Score / Group	0	1	2	3
Group I	6, 7 %	26, 7 %	36, 7 %	30, 0 %
Group II	16, 7%	43, 3 %	10, 0%	30, 0 %
Group III	20, 0 %	23, 3 %	26, 7 %	30, 0 %

None of the procedures investigated on our study completely eliminated the microleakage. The extent of dye penetration was lowest in the laser - treated and acid - etched group (Group II). We determined lower microleakage score for laser - prepared and laser - etched cavities (Group III) than for preparations with diamond bur and air - turbine (Group I) (Figure 1).

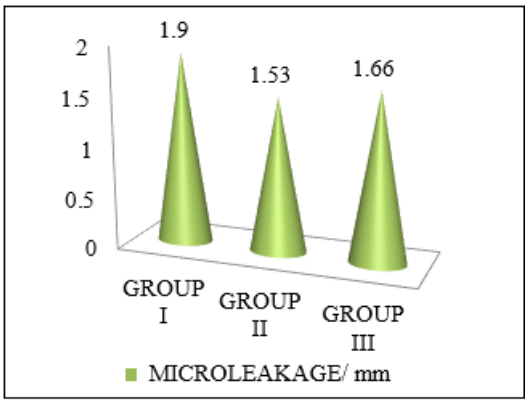

Figure 1: Microleakage results of experimental groups

There is no statistically significant difference in microleakage between the three experimental groups (p > 0, 05).

4. Discussion

Microleakage is among the most important challenges in restorative dentistry. Uncompleted diffusion of adhesive resin component via the outermost demineralized dentin will lead to non - resin infiltrated collagen networks low hydrolysis, the process that weakens the resin–collagen network over time. Decreasing or removing the collagen network in resin - dentin interface can improve the strength of bond and reduce marginal microleakage [14, 16, 17, 18].

The surface treated with an Er: YAG laser is clean, sterile, chalky and microscopically scratched to a depth of 70 μm [10]. The scientific studies found a minimal amount of debris and smear layer, in comparison with the conventional drill preparation, where 1 - 5 μm thick smear layer was formed. The smear layer decreases the bonding strength with the restorative material. Cavities prepared with a laser are ideal for definitive fillings of composite, glass - ionomer cement, compomer and ormocer. The studies of bond strength and marginal sealing of Er - laser - prepared cavities present conflicting results. Some authors recommended a technique of "laser etching". The conditioning of the enamel is achieved by using the lowest possible energy value, shortly before the ablation threshold is reached. Most studies, concluded that once Er: YAG laser radiation removes all organic ingredients, the formation of a hybrid layer is impossible. Only free adhesive tags inside the dentinal tubules were established [7]. The strength of the mechanical connection is deteriorated, the mechanical bond between the dental hard tissue and the composite material is decreased. This requires additional acid etching of the laser treated surface. It has been proven that laser treatment achieves 75% of the effect of the total acid etching. Due to the advantages of laser radiation on intertubular dentin and the higher acid resistance of irradiated dentin compared to the acid - treated, the self - etching adhesives are considered unsuitable [4, 5]. The limited effectiveness of the self - etching primer on the laser - irradiated dentin may be due to the limited ability of the acid monomers to demineralize the laser - modified surface layer and to transform the resulting morphological forms. Thus, a total etching technique is recommended. It ensures the presence of a microregular surface and opened dentinal tubules are microscopically

demonstrated, as well as a hybrid layer and adhesive tags in the dentinal tubules. The aim of the current research was to to investigate the marginal leakage of class V cavities prepared by conventional diamond bur and Er: YAG laser. The results revealed that the laser irradiation can modify the morphology of the cavity walls and increase the bond strength with the composite filling. The use of conventional diamond bur for cavity preparation yielded higher degree of marginal leakage as compared with both Er: YAG laser treated surface - with or without acid etching. It can be concluded that the application of high - energy laser irradiation may result in less microleakage than conventional methods of cavity preparation, especially combined with total - etch technique.

5. Conclusions

Certain lasers can modify the morphology of the cavity wall and increase the bond strength with composite fillings.

References

[1] Arami, S., S. Shahabi, M. Tabatabaie, N. Chiniforush, E. Morshedi, S. Torabi. Assessing microleakage of composite restorations in class V cavities prepared by Er: YAG laser irradiation or diamond bur. *Journal of Conservative Dentistry* 2014, 17 (3): 216 - 220

[2] Armengol V, Jean A, Enkel B, Assoumou M, Hamel H. Microleakage of class V composite restorations following Er: YAG and Nd: YAP laser irradiation compared to acid - etch: an in vitro study. *Lasers Med Sci.*2002; 17 (2): 93 - 100. doi: 10.1007/s101030200016.

[3] Baghalian A, Nakhjavani YB, Hooshmand T, Motahhary P, Bahramian H. Microleakage of Er: YAG laser and dental bur prepared cavities in primary teeth restored with different adhesive restorative materials. *Lasers Med Sci.*2013; 28 (6): 1453 - 60. doi: 10.1007/s10103 - 012 - 1222 - 0.

[4] Barcellos DC, Holleben P, Fonseca BM, Sabino BC, Gonçalves SEP. The effect of self - etching adhesive system associated with different energy densities of Nd: YAG laser on microtensile bond strength to dentin. *Lasers Dent Sci.*2018; 2 (3): 157 - 62. doi: 10.1007/s41547 - 018 - 0033 - 4.

[5] Celik EU, Kucukyilmaz E, Savas S. Effect of different surface pre - treatment methods on the microleakage of two different self - adhesive composites in Class V cavities. *Eur J Paediatr Dent.*2015; 16 (1): 33 - 8.

[6] Dayem RN. A novel method for removing the collagen network from acid - etched dentin by neodymium: yttrium - aluminum - garnet laser. *Lasers Med Sci.*2009; 24 (1): 93 - 9. doi: 10.1007/s10103 - 007 - 0528 - 9.

[7] Dayem RN. Assessment of the penetration depth of dental adhesives through deproteinized acid - etched dentin using neodymium: Yttrium - aluminum - garnet laser and sodium hypochlorite. *Lasers Med Sci.*2010; 25 (1): 17 - 24. doi: 10.1007/s10103 - 008 - 0589 - 4.

[8] Delme, K., P. Deman, R. de Moor. Microleakage of class V resin composite restorations after conventional and Er: YAG laser preparation. *Journal of Oral Rehabilitation* 2005 32; 676–685

[9] Golbari N, Kasraei S, Afrasiabi A, Mostajir E, Mojahedi SM. Effect of diode laser (810 nm) irradiation on marginal microleakage of multi - mode adhesive resins in class V composite restorations. *J Lasers Med Sci.*2019; 10 (4): 275 - 82. doi: 10.15171/jlms.2019.45.

[10] Kasraei, S., S. Karimi, M. Malek, M. Mohammadi. Influence of laser deproteinization of acid - etched dentin on marginal microleakage of class V composite restoration. *Brazilian Journal of Oral Sciences*, 2021, 20, 1 - 11

[11] Kawaguchi FA, Eduardo CP, Matos AB. Nd: YAG Laser Influence on Microleakage of Class V Composite Restoration. *J Clin Laser Med Surg.*2003; 21 (4): 227 - 9. doi: 10.1089/104454703768247800.

[12] Kimyai S, Ajami AA, Chaharom MEE, Oskoee JS. Comparison of microleakage of three adhesive systems in class V composite restorations prepared with Er, Cr: YSGG laser. *Photomed Laser Surg.*2010; 28 (4): 505 - 10. doi: 10.1089/pho.2009.2562.

[13] Lisboa DS, dos Santos SV, Griza S, Rodrigues JL, Faria - e - Silva AL. Dentin deproteinization effect on bond strength of self - adhesive resin cements. *Braz Oral Res.*2013; 27 (1): 73 - 5. doi: 10.1590/S1806 - 83242013000100013.

[14] Maeda FA, Fukushima KA, Tedesco TK, Aranha ACC, Raggio DP, Miranda Junior VG, et al. Effect of erosive challenge and Nd: YAG laser irradiation on bond strength of adhesive systems to dentin. *Int J Adhes Adhes.*2016; 64: 60 - 4. doi: 10.1016/j. ijadhadh.2015.09.008.

[15] Maior JRS, Figueira MAS, Netto ABAB, Souza FB, Silva CHV, Tredwin CJ. The importance of dentin collagen fibrils on the marginal sealing of adhesive restorations. *Oper Dent.*2007; 32 (3): 261 - 5. doi: 10.2341/06 - 75

[16] Rezaei - Soufi L, Kasraei S, Fekrazad R, Vahdatinia F, Moghimbeigi A, Haddad, et al. Evaluation of Diode laser (940 nm) irradiation effect on microleakage in class V composite restoration before and after adhesive application. *J Dent Mater Tech.*2018; 7 (1): 11 - 8.

[17] Savadi Oskoee S, Alizadeh Oskoee P, Jafari Navimipour E, Ahmad Ajami A, Pournaghi Azar F, Rikhtegaran S, et al. Comparison of the effect of Nd: YAG and diode lasers and photodynamic therapy on microleakage of Class V composite resin restorations. *J Dent Res Dent Clin Dent Prospects.*2013; 7 (2): 74 - 80. doi: 10.5681/joddd.2013.013.

[18] Shafiei F, Memarpour M, Fekrazad R. Sealing of Silorane - based Composite in Laser - prepared Primary Teeth: Effect of Acid Etching. *Pediatr Dent.*2014; 36 (5): 378 - 83.

[19] Ural Ç, Külünk T, Külünk Ş, Kurt M. The effect of laser treatment on bonding between zirconia ceramic surface and resin cement. *Acta Odontol Scand.*2010; 68 (6): 354 - 9. doi: 10.3109/00016357.2010.514720.

Author Profile

Dr. Dogandzhiyska is an assistant professor at the Department of Conservative Dentistry, Faculty of Dental Medicine, Sofia, Bulgaria. Her research interests are in the field of endodontics, aesthetic restorations and laser dentistry.